# Detecting Water on Mars

Time:
4-5 class periods

Objectives:
The lesson prepares students to interpret remote sensing images, a spectrograph image of Hydrogen, and a neutron spectrograph that will be used to analyze and detect the probability of water on Mars.

Students will analyze various methods of detecting the presence of water on Mars. Students will utilize remote sensing photographs, geologic models, neutron spectroscopy graphs, spectroscopy images, concept activities and current mission findings (Spirit and Odyssey), in substantiating the existence of water on Mars.
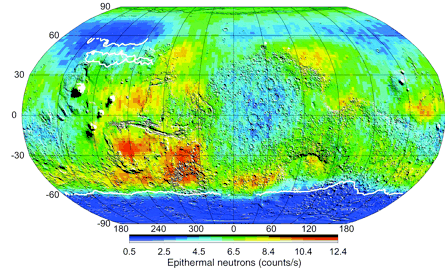
Content Standards:
Abilities necessary to do scientific inquiry

Understanding about scientific inquiry

The position of an object can be described by locating it relative to   another object or the background.

Vibrating objects produces sound. Changing the rate of vibration can vary the pitch of the sound.

Electricity in circuits can produce light, heat, sound, and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass.

People have always had questions about their world. Science is one way of answering questions and explaining the natural world and solar system.

Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure, and do.

Describe the shape and important features of a set of data and compare related data sets with an emphasis on how the data are distributed

Propose and justify conclusions and predictions that are based on data and design studies to further investigate the conclusions or predictions.

Apply and adapt a variety of appropriate strategies to solve problems.

Represent data using tables and graphs such as: line plots, bar graphs, and line graphs.

For the teacher:

Visuals of:
    a Neutron Spectrograph Map of the Mars
    Images of *Spirit* and *Opportunity*
    Spacecraft and their instrumentation
    (optional)
    http://www.space.com/php/multimedia/image
    display/img_display.php?pic=h_roverdetail_0
    2.jpg

    A neutron spectrograph
    For demonstration on neutron reaction
    activity:
    Magnet (10), 3 jars with different levels of
    water, steely (12), glass marble (3), a tray or
    boundary for catching marbles.
    Optional: representative rock samples of iron
    (basalt), magnesium (Olivine), and silicon
    (quartz).
    Evaluation of Spectroscopy

The teacher will demonstrate knowledge and use
of spectroscopy, neutron spectroscopy, core
sampling, stratigraphy, and hydro-porosity of soils.

For each group of 3 to 4 students:

Copies of:
    Epithermal Neutron map image
    Epithermal Core Neutron Data (Assign
    one core sample per group),
    a blank Neutron Data Graph,
    Epithermal Neutron Count Graph (for
    normalizing data), and
    a blank Weight Percentage of Water
    Graph

Data collected from the use of the Gamma-Ray Spectrometer on the Mars Odyssey provides evidence of areas on Mars that are enriched in Hydrogen (H). The presence of Hydrogen on Mars does not provide proof of the existence of water, Hydrogen present in the form of physically or chemically bound H_2O, but the evidence suggests a strong volatility dependence similar to that expected for ice.

Three instruments used on the Mars Odyssey mission are the Gamma Subsystem, the Neutron Spectrometer, and the High Energy Neutron Detector. The techniques of gamma ray and neutron spectroscopy rely on cosmic-ray particles acting as an excitation source. Through a process of excitation and de-excitation, emission of detectable gamma rays provide evidence of varying chemical elements. Hydrogen is especially effective at moderating neutrons.
When stars in our galaxy die they generate waves that accelerate cosmic rays that enter our solar system and hit planet surfaces. After a cosmic ray hits a surface it generates neutrons. These neutrons then hit other elements, and send out gamma rays that have different "sounds"(which represent gamma ray energies). Each element that is hit has its own signature sound. Gamma Ray Spectrometers detect the gamma ray that is unique to each element.

The neutron spectrometer allows scientists to count the number of neutrons that are scattered by the collisions. Some of the different elements scientists are looking for are: Hydrogen (H), Carbon (C) Oxygen (O), Magnesium (Mg), Aluminum (Al), Silicon (Si), Calcium (Ca), Chlorine (Cl), Titanium (Ti), Iron (Fe), Potassium (K), Thorium (Th), and Uranium (U).

Student Skills

Students need an understanding of spectroscopy as a way of studying which atoms absorb and emit electromagnetic radiation. Spectroscopy allows astronomers to study the chemical composition of planets, moons, stars and so on from afar because of the way atoms absorbs and emits light.

To look at a Mars Surface Spectrograph go to: http://www.iki.rssi.ru/hend/e_page2_main.htm

Students should understand the basic sub-atomic particles that make up atoms and hydrogen in particular. In this lesson, students will model neutron interactions between different elements, and interpret an epithermal neutron map of Mars. Students will also graph epithermal neutron data from a hypothetical core sample, normalize their data, and produce a graph of stratigraphic water content.

Questions about Mars Spectroscopy

What does the surface of Mars consist of?
How did Mars form and how has it changed?
Is there a water table within three feet of the Martian surface?
Has there been standing water on the surface of Mars?
What will Mars be like in the future?
What is a spectrograph?
What does a map of epithermal neutron fluxes from a neutron spectrograph tell us about hydrogen on Mars?
What previously unknown information can be collected from a Mars core sample neutron spectrograph?
Why is it important that we look for water/hydrogen on Mars?
Where are the best places on Mars to look for the fossil remains of life or microbial communities?

Demonstration Activity

Shoot a glass marble (cosmic ray) at the element !

Steelies
(Element)

Magnet - H

Fe

Si

Jar

Mg
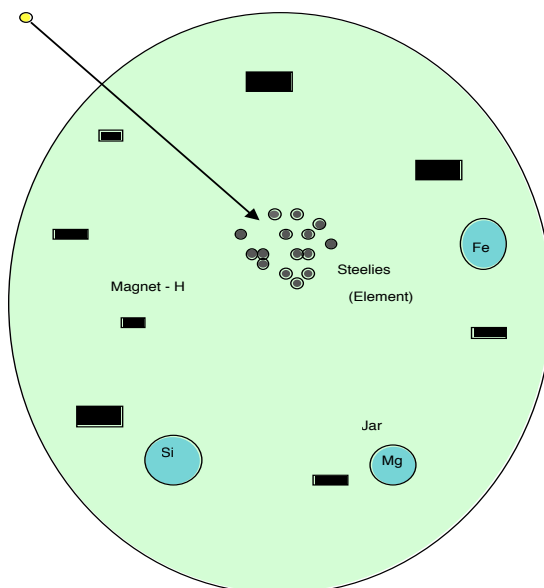
Place several magnets representing Hydrogen (H) atoms, a one-quarter filled jar of water representing Silicon (Si), a one-half filled jar representing Magnesium (Mg), and a three-quarter filled jar representing Iron (Fe), in a circular pattern along the periphery, each about 5 inches away from of a cluster of steel marbles. Set a cluster of a dozen or so steel marbles in the center of the model. Explain to students that you will be shooting a marble to represent a cosmic ray striking an element on the Mars surface that is represented by the cluster of steely marbles. The steel marbles represent the neutrons in this element. When it is bombarded by a cosmic ray, it will shoot out neutrons that then collide with other elements on the Martian surface. The jars and magnets represent other elements in the crust. As the neutrons hit the different jars,

they will make different sounds representing the different neutron signature sounds that a neutron spectrometer records from different elements. Since Hydrogen (H) is merely a proton with an orbiting electron, it will absorb a bombarding neutron and therefore not produce any signature sound. For this reason Hydrogen (H) has a low epithermal signature.

Challenge
Show students the following Epithermal Neutron Map of the Mars surface Analyze the low epithermal fluxes for Hydrogen (H). Ask students to describe any patterns or logic in the image map. Are there any similarities with earth?

To explain how the mapping was acquired from Odyssey, go to:
http://www.lanl.gov/orgs/pa/News/MarsOdyssey.html
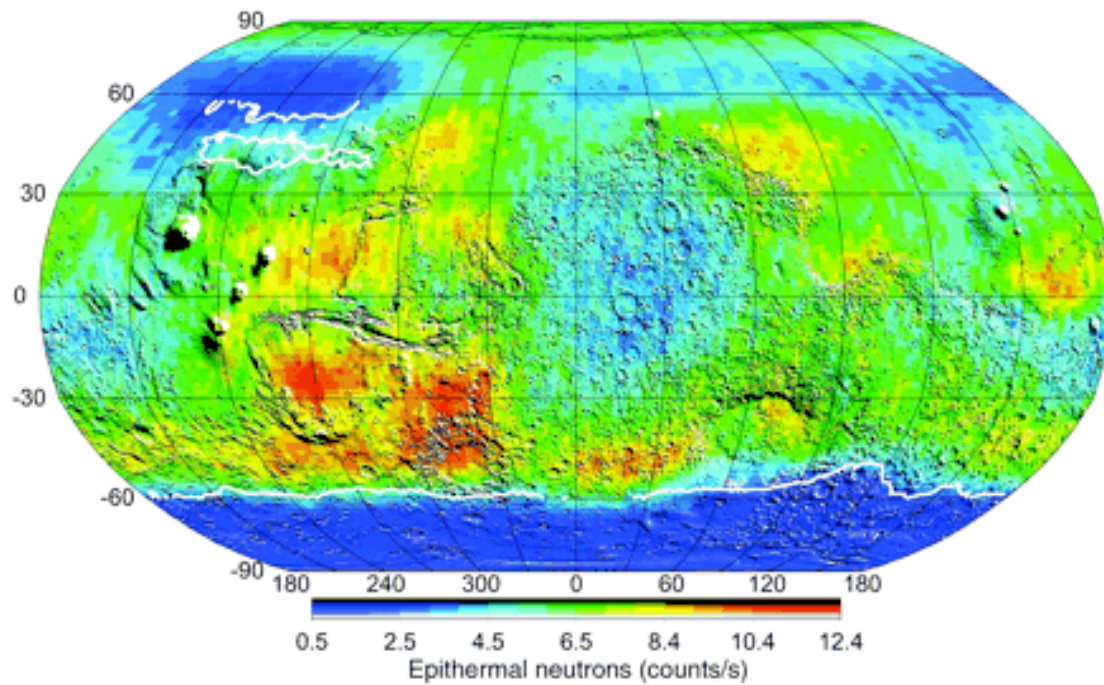
To provide students with a larger image of this map, see Figure 1.

More information can be found at:

http://www.sciencemag.org/cgi/content/full/297/5578/81?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&searchid=1060273802703_5117&stored_search=&FIRSTINDEX=0&volume=297&firstpage=81&fdate=10/1/1995&tdate=8/31/2003

For additional imaging go to:
http://grs.lpl.arizona.edu/results/agu1202/
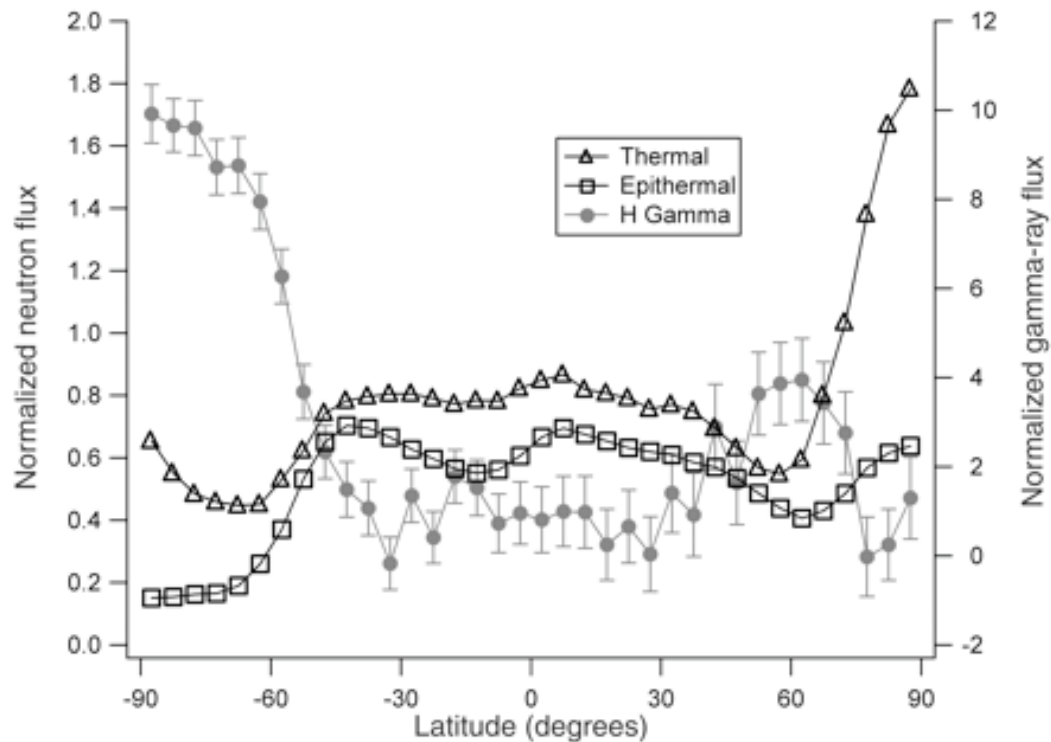
Normalized fluxes of neutrons and H gamma rays versus latitude. The data are averaged over longitudes 90° to 210°E. These longitudes were chosen to be as far as possible from the residual CO2 cap in the south, which could have a major effect on the flux of thermal neutrons, similar to that observed in the north due to the seasonal CO2 frost. The increase in H gamma-ray emission south of about -45° is clearly evident, as is an enrichment in the north. The enrichment in the north does not continue to the pole because the north polar region is currently covered by a thick seasonal CO2 cap. Note the anticorrelation between the H gamma-ray flux and the epithermal neutron flux.

Emphasize that Hydrogen (H) has a low epithermal signature because it absorbs neutrons. This graph (Figure 2) was produced during a Northern hemisphere winter, during which time CO_2, or dry ice, covered the North Pole. Notice the data reversal in the northern polar region. As the gamma ray hits the surface, it only comes into contact with the dry ice, no Hydrogen (H). Even in areas without the dry ice, the map only detects at the surface. Scientists want to know more about the underlying stratigraphic layers of Mars. Is there any subsurface water? How could we explore Mars more? How do we find out about underlying stratigraphy on earth? Normally we would drill! Can we drill on Mars? Well that is what the Mars Rover on the Spirit and Opportunity Missions are planning to do after landing on January 4th and 25th, 2004!

To find out about the constituents of the underlying layers of Mars, the new missions are carrying probes for conducting Gamma Ray Spectrometry (GRS). The instruments are designed to drill a 30-cm core hole and insert a gamma ray spectrometer (GRS). The epithermal neutron signatures for the different layers of rock and soil will be retrieved and relayed to earth.

For more information on how the GRS works:
http://mars.jpl.nasa.gov/odyssey/technology/grs.html

For the following activity, we will assume that the students are scientists at the Los Alamos National Laboratory, who developed the Gamma Ray Spectrometer for these missions, and are

now receiving and interpreting the data. Give each group of students one of the sample core readings and ask them to identify the stratigraphic layers by using Table 1 for comparison.

For more information on the Gamma Ray Spectrometer built by Dr. William Feldman at Los Alamos Laboratories: http://grs.lpl.arizona.edu/instruments/ns/

Epithermal Neutron Core Data from Mars

Depth	Sample A	Sample B	Sample C
0		1	0.68
2	1		
4		0.43	1
6	0.98	1	
8		0.42	0.98
10	0.67		
12			
14		1	0.87
16	0		
18			0
20	0.41		
22		0.44	
24			0.41
26	0.99		
28			
30			

Depth	Sample D	Sample E	Sample F
0	0.46	0.63	0.68
2			
4		0	1
6	0		
8	0.28	0.47	0.98
10			
12	0.99		
14		0	0.87
16	0		
18		0.42	0
20	0.45		
22			
24		0.22	0.41
26			
28			
30			

Table 1

Rounded Epithermal Neutron Signatures	"Hypothetical" Stratigraphy
1.0	Basalt
0.8	Olivine
0.6	Volcanic Ash/Tuff
0.4	Sandstone
0.2	Sand
0	Alluvial Mix

Hypothetical Stratigraphy and representative Epithermal Neutron Signatures.
Note that the lower the epithermal signature, the greater the abundance of
Hydrogen and porosity of the stratigraphic layer.

Have students graph their epithermal neutron counts from their core sample onto a blank Neutron Data Graph.

**Neutron Data Graph**
(see Figure 2 for larger copy)
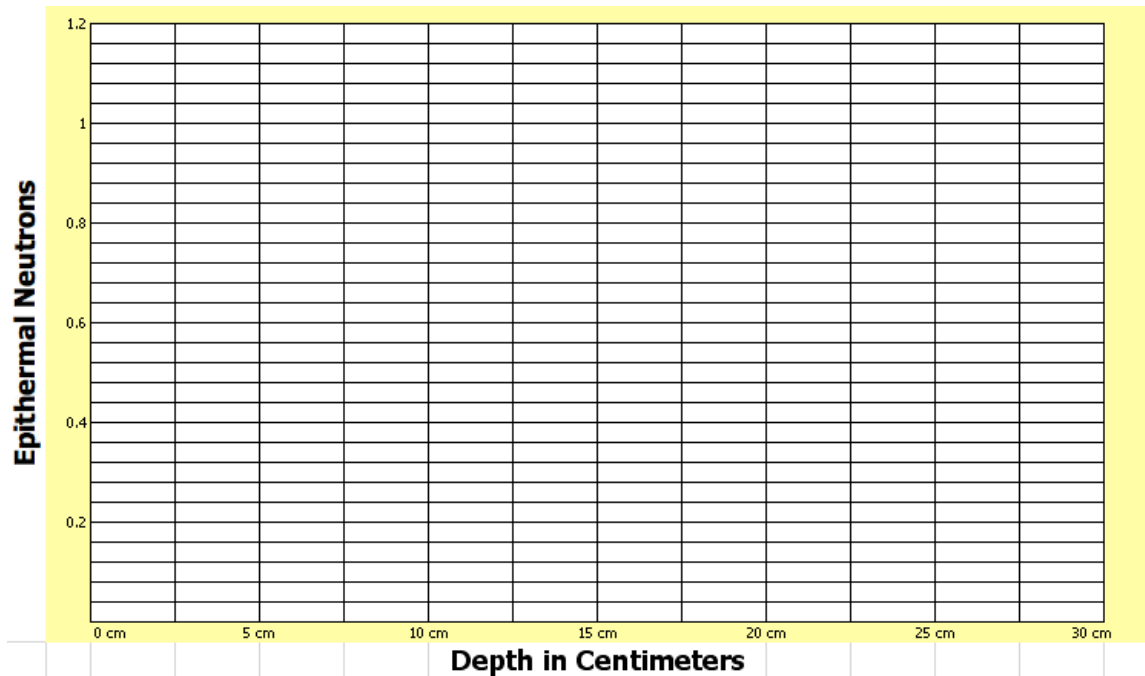
Ask students to extrapolate information from their Neutron Data Graphs. What can they infer from the data?

Refer to the Epithermal Neutron Counts Graph. Students will use this graph to normalize their data. Students are to predict the water content of each stratigraphic layer of rock and soil. Students will then plot the percentage by weight of water in their Core Sample onto another graph.
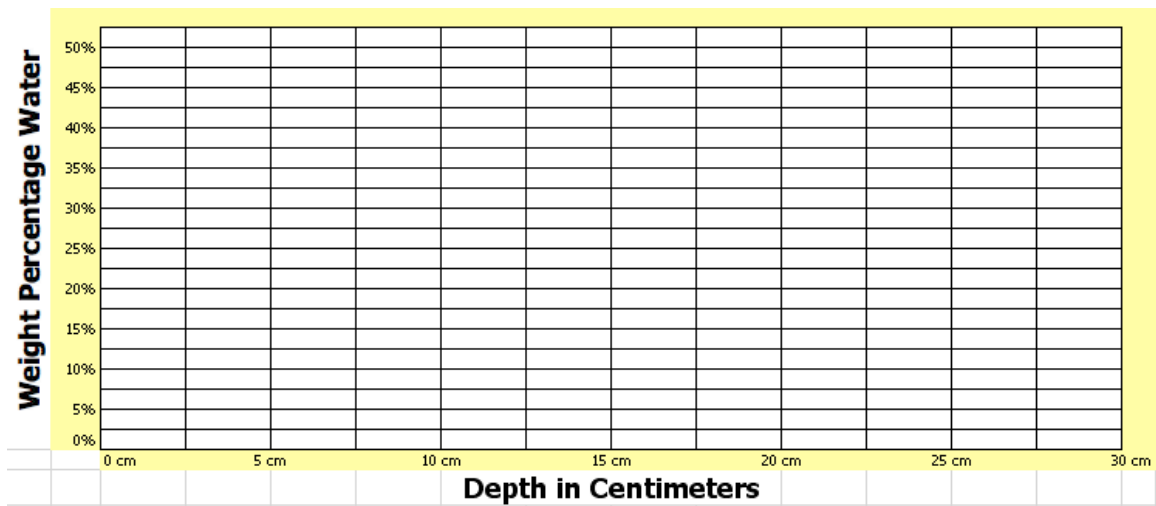
Epithermal Neutron Counts
(see Figure 3 for larger copy)
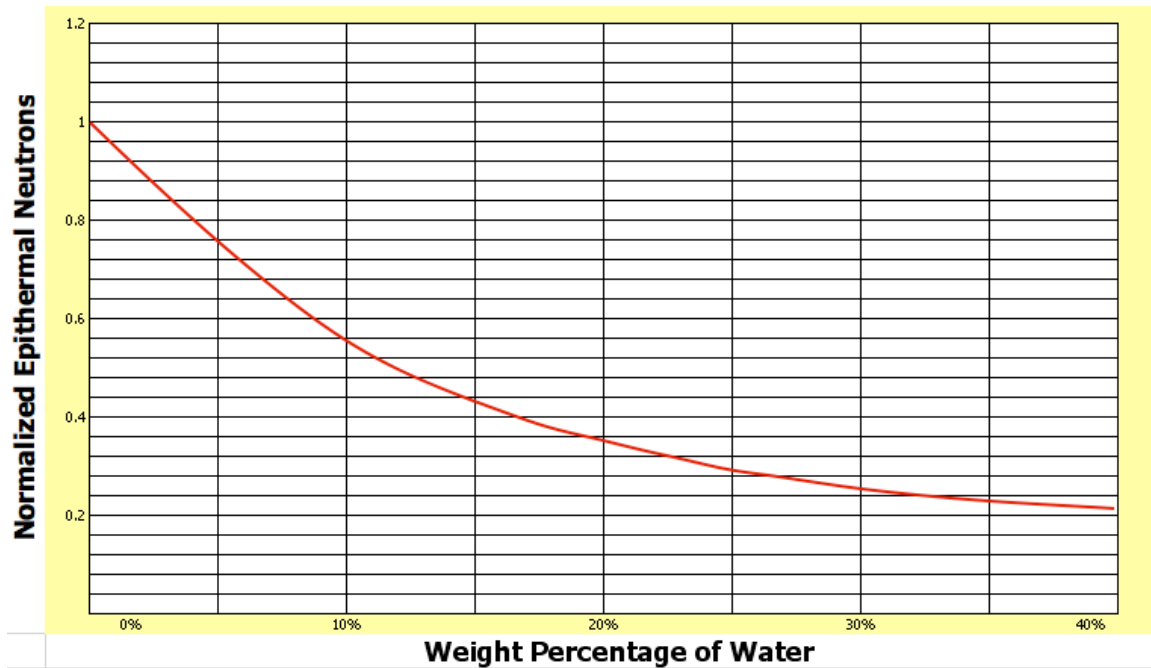
Percentage of Water in Core Sample
(see figure 4 for larger copy)

The data in this activity is hypothetical. More realistic data will be relayed back to earth when Spirit and Opportunity land on Mars in January 2004, so stay tuned! What do you think they will find? Ask students to create their own hypothetical data set of what they think scientists will find.

Assessment:

Create a hand drawn stratigraphic layer with at least 5 different stratigraphic layers. Identify the latitude of your core sample in your Title. Using your own graph paper graph the corresponding Epithermal Neutron Count and Percentage by Weight of Water for your particular core sample.

Questions & Closure:

Assume we find more evidence of water on Mars. Why is this important? Would it be possible for life to exist on Mars? Why or why not?

For demonstration purposes, create a model of a short strand of DNA (Magz@ magnets work well). Fire a model radiation particle (foam ball with a slingshot) at the DNA and watch it break. Explain to students that this is what radiation does to DNA.

Is it possible for life to exist on Mars? Discuss.

Extension:

Split the class in half. Ask students to use the scientific method in establishing evidence proving or disproving the possible existence of life on Mars now or in the past. Use the Internet to look for information about the planet that either supports or diminishes the theory that life could exist or has existed on Mars! Be sure to study the magnetosphere, the planet's origin, weather and other parameters about Mars.
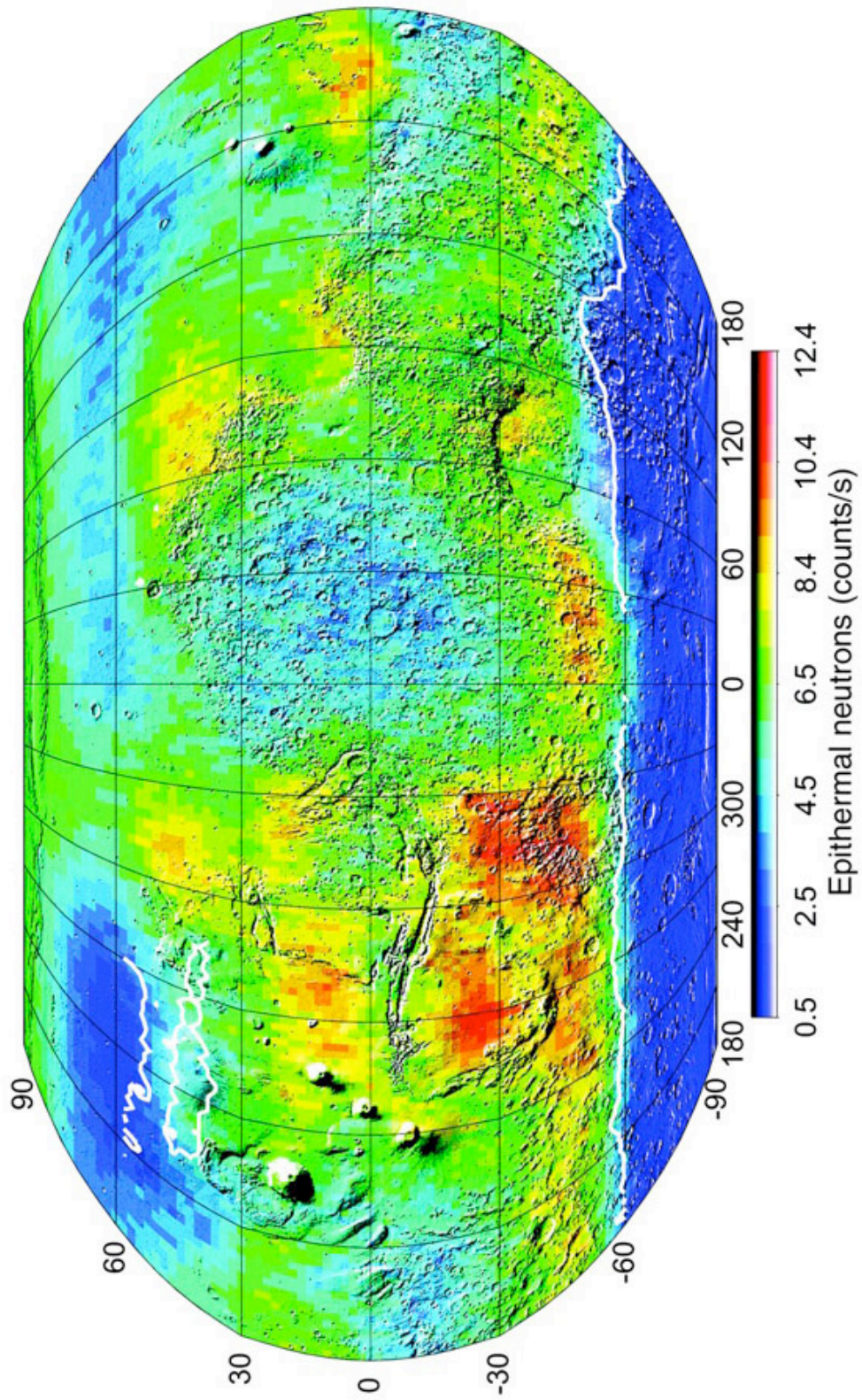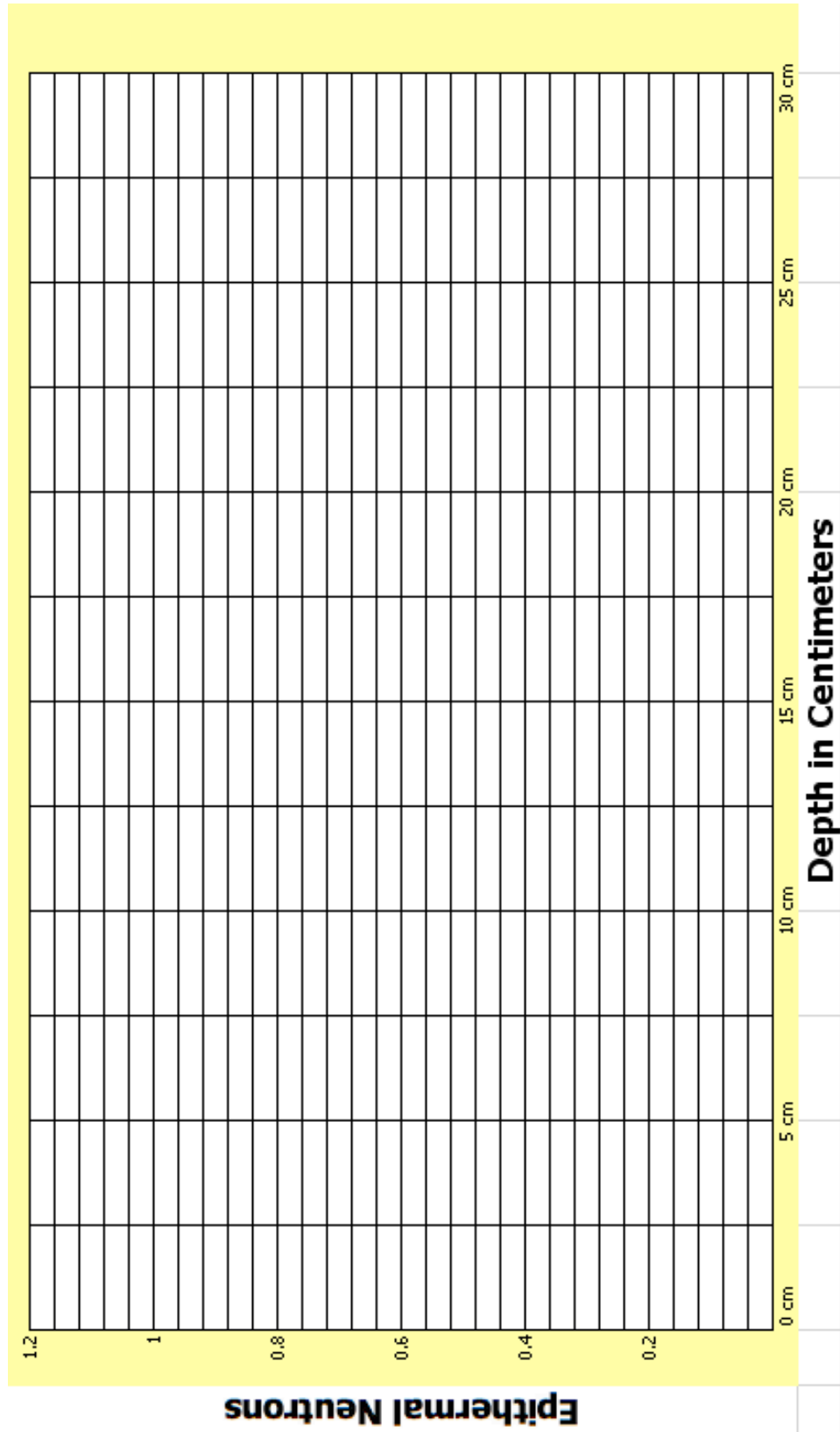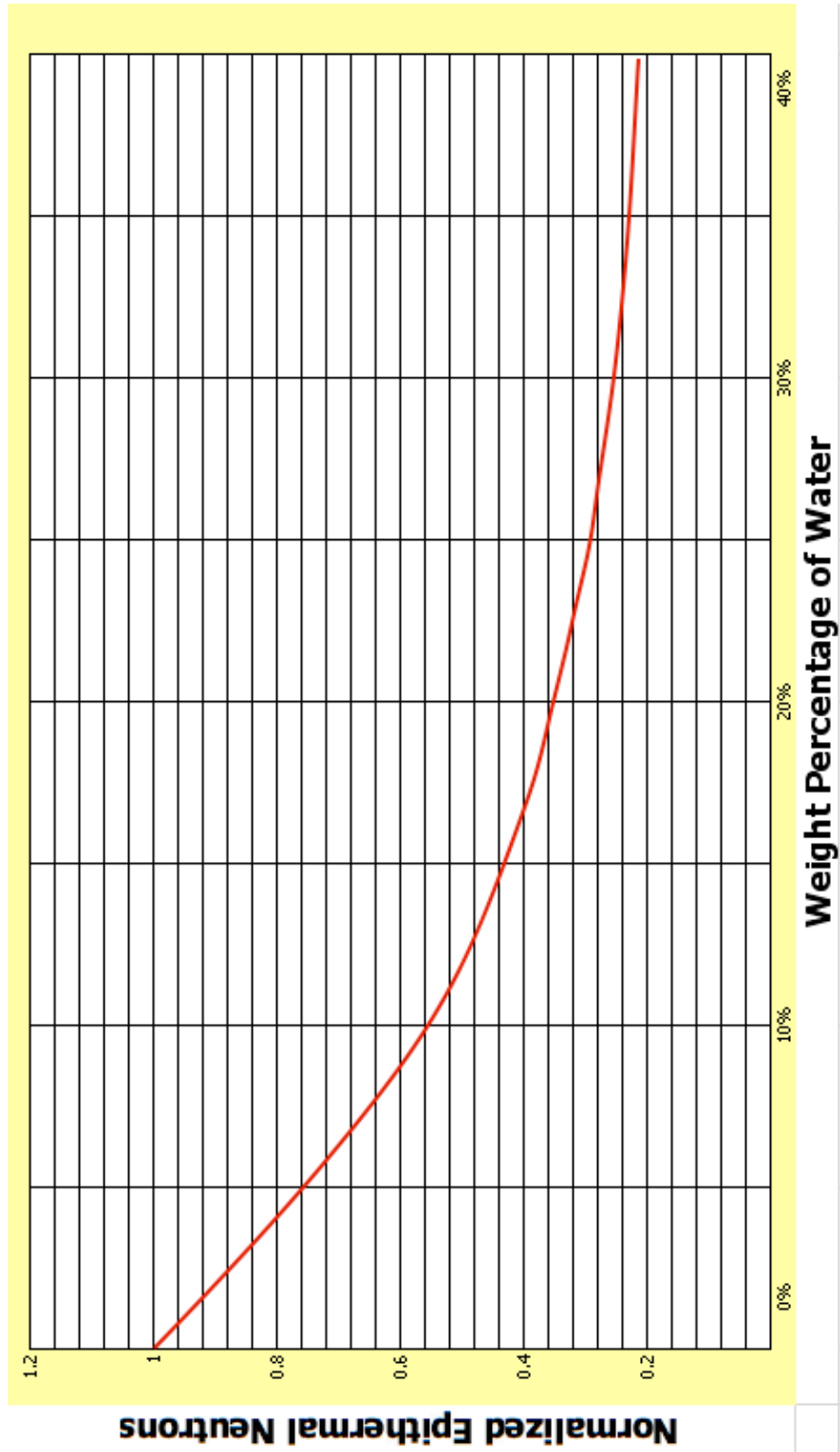
Figure 1

Figure 2

Figure 3

Figure 4